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Site 300 Bat Monitoring Final Report

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Disclaimer

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To: Lisa Paterson, LLNL

From: Joe Drennan and Justin Tortosa

Date: July 18, 2016

RE: Site 300 Bat Monitoring, Final Report

Garcia and Associates (GANDA) was contracted by the Lawrence Livermore National Laboratory (LLNL) to design and execute a long-term passive bat monitoring program for Site 300, southwest of Tracy, California. This effort included consulting and collaborating with LLNL staff for the acquisition of monitoring equipment, data collection, data storage, data transfer and data analysis.

Methods

Equipment, Installation, and Data Management

In April 2015, GANDA provided a recommendation to purchase the following equipment:

- 2—Wildlife Acoustics SM3 BAT units.
- 3—SMM-U1 microphones
- 3—50-meter SM3 microphone cables
- 1—10-meter cable
- 1—Ultrasonic calibrator (to test the sensitivity of each microphone)
- 8—128GB SDXC Class 10 Flash Cards
- Batteries (4 D cell per unit)

From June 15 to 18, 2015, GANDA biologist Graham Neale assisted in programming and field-testing of the bat monitoring equipment. The equipment was deployed in the field on a meteorological (MET) tower within Site 300 on June 18, 2015.

The Wildlife Acoustics system Song Meter SM3BAT was selected based on its durable field design, recording quality, large storage capacity, low power requirements and its efficient analysis software, Kaleidoscope Pro 3 Analysis.

Two weather resistant Wildlife Acoustics SMM-U1 ultrasonic microphones were attached to the Site 300 MET tower, one at 52 meters and one at 23 meters on existing equipment booms. An aluminum clamp was fabricated to attach each microphone to the booms. The configuration of the boom unfortunately required that the microphones be oriented to the west, which generated more wind and noise files due to the prevailing winds. This issue was finally addressed by the addition of foam microphone covers (see below). The cables were bundled with other cables on the tower and attached to the SM3BAT unit mounted at the base of the tower. Rechargeable batteries were used to power the unit and SDXC compact memory cards with 64 gigabytes of memory were used.

When feasible, batteries and data cards were exchanged weekly. Data was copied to a LLNL computer hard drive, and uploaded to the online sharing platform Dropbox. The data was then downloaded to GANDA servers, and also backed up on GANDA's online data storage website. This system provided redundancy for data storage with a minimum of three copies in three separate locations. With the exception of the files from July 22, 2015; October 7 and 28, 2015; December 2 and 9, 2015; January 13 and 20, 2016; February 10, 2016 and March 16, 2016 each weekly monitoring period recorded at least one bat call file.

In 2015, data files were transferred on July 8, 15, 22, 29; August 5, 12, 19, 26; September 2, 9, 16, and 23; October 7, 13, 21, 28; November 6, 11, 18, 25; December 2, 9, 16, 22, 29. In 2016, data files were transferred on January 6, 13, 20, 27; February 3, 10, 17, 24; March 2, 10, 16, 23, 30; April 13, 20, 27; and May 4, 11, 18, 25.

The 52-meter cable broke sometime between the August 6 and September 2, 2015 data collection visits. The apparent cause was contact with a metal edge on the MET tower. It was replaced on the September 16, 2015 visit, and subsequent analysis confirmed the microphone was working properly. On the September 2, 2015 visit, the data recorder was updated with a Wildlife Acoustics firmware patch, and foam microphone covers were added to reduce wind and rain noise recordings.

Data Analysis

Bat call files are created when a bat passes near the microphone while calling. Call quality and duration are affected by the distance of the bat to the microphone, and the orientation to the microphone (whether the bat is facing the microphone, flying away, or turning while calling). The identification software evaluates call quality and determines if there are enough call characteristics to meet parameters required to save the call for identification.

Call analysis and identification was accomplished with a two-step process. First, the Wildlife Acoustics Kaleidoscope Pro 3 Auto ID software was used to convert the Wildlife Acoustics formatted files, sort them to remove noise and low-quality files, and categorize the remaining call files by species. The software uses a large database of sample-call characteristics collected from each species throughout their range. This library is updated regularly (Wildlife Acoustics 2015a).

The process is further defined by selecting classifiers for North America and California. This limits the software choices to species known to exist in the study area, increasing accuracy of identification and decreasing batch processing times. The software processes large batches of files, identifies and removes noise files and those with an insufficient amount of data for adequate analysis, and then provides species identification along with a number of statistics to allow the biologist to evaluate the accuracy of the identification.

The Wildlife Acoustics software has proven effective in handling large batches of data and visually displaying them for analysis, but due to variation in call file characteristics, similarity in the calls of certain species, and localized dialects of wide-ranging species, the software analysis results are not sufficiently robust at this time. Therefore the second step in the process was to have an expert in bat identification subsample the call file sonograms produced by the Wildlife Acoustics software. For this effort, GANDA bat biologist Justin Tortosa was asked to review samples of the sonogram identifications. These sonograms were produced prior to the software identification process, and were visually compared to known calls from bats likely to occur in northern California (CDFW 2016). These included pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), western red bat (*Lasiurus blossevillii*), hoary bat (*Lasiurus cinereus*), canyon bat (*Parastrellus hesperus*), California myotis (*M. californicus*), small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), fringed myotis (*M. thysanodes*), Yuma myotis (*Myotis yumanensis*), little brown bat (*M. lucifugus*), long-legged myotis (*M. volans*), Brazilian free-tailed bat (*Tadarida brasiliensis*) and western mastiff bat (*Eumops perotis*)   Many species have overlapping call parameters, and are therefore placed into frequency categories (50 kHz myotis [Yuma myotis and California myotis], 40 kHz myotis [long-legged myotis, little brown bat and small-footed myotis] and 25 kHz bats [big brown bat, silver-haired bat and sometimes pallid bat) rather than identified to species. The categories are useful in identifying potential species, but accurate identification for most of these species cannot be determined without mist-netting and capture. Some species placed in a frequency category have unique aspects to their call signatures (e.g., presence of social calls, maximum frequency, call duration) that allow for accurate identification. Both approaches provide useful information and are presented in this report.

Results

Eleven species have been identified by analyzing 1,012 call files. The Kaleidoscope Pro 3 Auto ID software identified the big brown bat, silver-haired bat, hoary bat, Yuma myotis, canyon bat, Mexican free-tailed bat, western red bat, fringed myotis pallid bat, little brown myotis, and California myotis. The species documented by file date are summarized in Table 1.

The results of the biologists' analyses were similar to the Wildlife Acoustics software, although less specific due to the overlap in call characteristics described above. The calls identified by Wildlife Acoustics software as big brown bat and silver-haired bat were re-grouped by the biologist in the frequency subclass of 25 kHz (unless the call exceeds 60 kHz, it is extremely difficult to differentiate between silver-haired bats and big brown bats). Although the largest number of calls were attributed to hoary bats, the biologist review found some to resemble 25 kHz bats or Mexican free-tailed bats. The Yuma and California myotis calls were indistinguishable and were therefore lumped into the 50 kHz frequency category. The call identified by the Wildlife Acoustics software as fringed myotis ranged from 25 kHz to 50 kHz, and was not consistent with other known calls for this species (i.e., steep frequency modulation with a wide band ranging from 25 kHz to 80 kHz). Furthermore, this myotis species is not known to occur at Site 300 (Rainey and Pierson 2004). Canyon bat matched the Wildlife Acoustics analysis, as did the Mexican free-tailed bat.

A review of the sonograms for the three remaining species— pallid bat, western red bat, and little brown bat—suggests that these species had been misidentified by the Wildlife Acoustics software. The pallid bat sonograms lacked social calls, and the western red bat sonogram was cluttered with insect calls. However, the presence of pallid bat and western red bat at Site 300, as demonstrated by Rainey and Pierson (2004), suggests these species are present at Site 300 but infrequently encountered at the single sampling location used in this study. With regards to little brown myotis, the sonogram only contained two pulses and was not considered detailed enough for identification. Little brown bat is one of the three myotis species included in the 40 kHz myotis acoustic group described above. Of those three species, the distribution and habitat preferences of long-legged myotis suggests that it is the most likely to occur at Site 300 (Rainey and Pierson 2004).

Both methods of analysis support the conclusion that the most abundant species at Site 300 are the hoary bat and the Mexican free-tailed bat. Two relatively common species, silver-haired and big brown bats, also likely occur in the project area because they are present in the region, and habitat exists for them in Site 300. Canyon bats were identified in smaller numbers by the Wildlife Acoustics software and the confirmation of their calls by the biologist indicate they could be present in Site 300. The data supports the presence of both Yuma and California myotis.

Identification rates for several species increased in September, including hoary, Mexican free-tailed, silver-haired, and big brown bats, then decreased in early October through December. This pattern indicates migration of these species in September and early October, with the number of call files recorded peaking on September 16 (115 call files), and September 23 (163 call files). These results are expected based on the documented presence and habitat use of these species in the region outside of Site 300.

Some species overwintered in or near Site 300, which is evident from the calls recorded in January and February, while some likely passed through to wintering grounds further to the south (Table 1). An increase in recorded calls beginning in March and peaking in April suggests movement to summer and maternity habitat.

Further information on these species is provided in Table 2, which describes each species' state and federal status, migratory behavior (may be indicative of when they are documented at Site 300), and their habitat requirements.

Table 1. Wildlife Acoustics software identification analysis data collection date, total number of calls on that date, bat species, and number of identified calls for each species at Site 300 in parentheses.

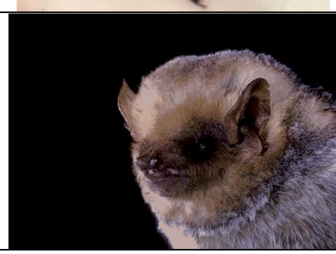
Date file Uploaded (total # of files identified)	**Big brown bat (*Eptesicus fuscus*)[1]**	**Hoary bat (*Lasiurus cinereus*)**	**Canyon bat (*Parastrellus hesperus*)**	**Mexican free-tailed bat (*Tadarida brasiliensis*)**	**Yuma myotis (*Myotis yumanensis*)[3]**	**Silver-haired bat (*Lasionycteris noctivagans*)[1]**	**Western red bat (*Lasiurus blossevillii*)**	**Fringed myotis (*Myotis thysanodes*)**	**Pallid bat (*Antrozous pallidus*)**	**Little brown myotis (*Myotis lucifugus*)[2]**	**California myotis (*Myotis californicus*)[3]**
7/8/15 (2)	X (1)	X (1)	-	-	-	-	-	-	-	-	-
7/15/15 (3)	-	X (2)	X (1)	-	-	-	-	-	-	-	-
7/22/15 (0)	-	-	-	-	-	-	-	-	-	-	-
7/28/15 (8)	-	X (4)	X (2)	X (2)	-	-	-	-	-	-	-
8/5/15 (6)	-	X (4)	-	X (1)	X (1)	-	-	-	-	-	-
8/12/15 (14)	X (2)	X (6)	-	X (5)	-	X (1)	-	-	-	-	-
8/19/15 (37)	X (2)	X (16)	X (2)	X (16)	-	X (1)	-	-	-	-	-
8/26/15 (48)	X (2)	X (21)	X (3)	X (22)	-	-	-	-	-	-	-
9/2/15 (20)	X (4)	X (11)	-	X (4)	-	X (1)	-	-	-	-	-
9/9/15 (79)	X (9)	X (20)	X (2)	X (43)	X (1)	X (4)	-	-	-	-	-
9/16/15 (115)	X (4)	X (59)	-	X (43)	-	X (9)	-	-	-	-	-
9/23/15 (163)	X (5)	X (28)	X (3)	X (106)	-	X (21)	-	-	-	-	-
10/7/15 (0)	-	-	-	-	-	-	-	-	-	-	-
10/13/15 (82)	X (5)	X (44)	X (1)	X (26)	-	X (6)	-	-	-	-	-
10/21/15 (29)	-	X (17)	-	X (11)	-	X (1)	-	-	-	-	-
10/28/15 (0)	-	-	-	-	-	-	-	-	-	-	-
11/6/15 (14)	X (1)	X (8)	-	X (4)	-	X (1)	-	-	-	-	-
11/11/15 (3)	X (1)	X (2)	-	-	-	-	-	-	-	-	-
11/18/15 (5)	X (1)	X (4)	-	-	-	-	-	-	-	-	-
11/25/15 (13)	-	X (10)	-	X (3)	-	-	-	-	-	-	-
12/2/15 (0)	-	-	-	-	-	-	-	-	-	-	-
12/9/15 (0)	-	-	-	-	-	-	-	-	-	-	-
1/6/16 (3)	-	X (2)	-	-	-	X (1)	-	-	-	-	-

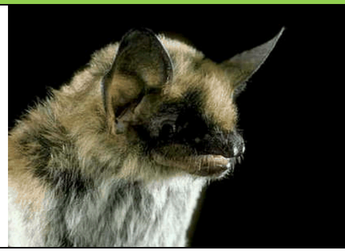
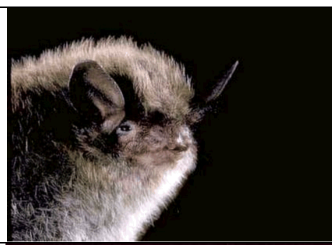
Date file Uploaded (total # of files identified)	Big brown bat (*Eptesicus fuscus*)[1]	Hoary bat (*Lasiurus cinereus*)	Canyon bat (*Parastrellus hesperus*)	Mexican free-tailed bat (*Tadarida brasiliensis*)	Yuma myotis (*Myotis yumanensis*)[3]	Silver-haired bat (*Lasionycteris noctivagans*)[1]	Western red bat (*Lasiurus blossevillii*)	Fringed myotis (*Myotis thysanodes*)	Pallid bat (*Antrozous pallidus*)	Little brown myotis (*Myotis lucifugus*)[2]	California myotis (*Myotis californicus*)[3]
1/13/16 (0)	-	-	-	-	-	-	-	-	-	-	-
1/20/16 (0)	-	-	-	-	-	-	-	-	-	-	-
1/27/16 (2)	-	X (2)	-	-	-	-	-	-	-	-	-
2/3/16 (11)	-	X (2)	X (1)	X (5)	-	X (2)	X (1)	-	-	-	-
2/10/16 (0)	-	-	-	-	-	-	-	-	-	-	-
2/17/16 (9)	-	X (6)	-	X (1)	-	X (1)	-	X (1)	-	-	-
2/24/16 (1)	-		-	-	-	X (1)	-	-	-	-	-
3/2/16 (14)	X (1)	X (8)	-	X (5)	-		-	-	-	-	-
3/10/16 (16)	-	X (13)	-	X (2)	-	X (1)	-	-	-	-	-
3/16/16 (1)	-		-	-	-		-	-	X (1)	-	-
3/23/16 (19)	X (2)	X (10)	-	X (4)	-	X (3)	-	-	-	-	-
3/30/16 (4)	X (1)	X (2)	-	-	-	X (1)	-	-	-	-	-
4/13/16 (33)	X (3)	X (22)	-	X (5)	-	X (3)	-	-	-	-	-
4/20/16 (77)	X (10)	X (43)	-	X (14)	-	X (9)	-	-	X (1)	-	-
4/27/16 (27)	X (4)	X (12)	-	X (8)	-	X (2)	-	-	X (1)	-	-
5/4/16 (66)	X (6)	X (37)	-	X (16)	X (1)	X (3)	-	-	X (2)	X (1)	-
5/11/16 (42)	X (5)	X (19)	-	X (5)	-	X (12)	-	-	X (1)	-	-
5/18/16 (42)	X (3)	X (16)	-	X (7)	-	X (15)	-	-	-	-	X (1)
5/25/16 (4)		X (4)	-	-	-	-	-	-	-	-	-
Total (641)	**72**	**455**	**15**	**358**	**3**	**99**	**1**	**1**	**6**	**1**	**1**

1 = 25 kHz bats, a group of three bats with similar call characteristics that echolocate in the 25 kHz frequency range.
2 = 40 kHz myotis, a group of five bats with similar call characteristics that echolocate in the 40 kHz frequency range.
3 = 50 kHz myotis, a group of two bats with similar call characteristics that echolocate in the 50 kHz frequency range.

Table 2. Documented species' status, migratory behavior, and habitat characteristics.

Species	Image	State Status	Federal Status	Migration	Habitat
Big brown bat EPFU (*Eptesicus fuscus*)		None	None	No	Prefers to roost in anthropomorphic structures, including buildings, mines, and bridges, but it has also been found in caves and crevices in cliff faces. Forages within a few kilometers of its roost, generally pursuing prey in tree canopies, over meadows, or along water courses.
Hoary bat LACI (*Lasiurus cinereus*)		None	None	Yes	Hoary bats are solitary and roost primarily in foliage of both coniferous and deciduous trees. Roosts are usually at the edge of a clearing. Roosts have also been reported in caves, beneath a rock ledge, in a woodpecker hole, in a grey squirrel nest, under a driftwood plank, and clinging to the side of a building.
Canyon bat PAHE (*Parastrellus hesperus*)		None	None	No	The smallest of North American bats. Associated with rocky canyons, outcrops, mines and caves where they roost in small crevices. Have been observed at dusk flying over creosote bush scrub several miles from rocky areas, and may roost under rocks or in rodent burrows.

Species	Image	State Status	Federal Status	Migration	Habitat
Mexican free-tailed bat TABR (*Tadarida brasiliensis*)		None	None	Yes	Most commonly associated with dry, lower-elevation habitats, but also occurs in a variety of other habitats, and is found up to at least 3,000 meters in some of the western mountain ranges.
Yuma myotis MYYU (*Myotis yumanensis*)		None	None	Not well understood over a fairly large western range	Associated with permanent sources of water, typically rivers and streams. It occurs in a variety of habitats including riparian, arid scrublands and deserts, and forests. Roosts in bridges, buildings, cliff crevices, caves, mines, and trees.
Silver-haired bat LANO (*Lasionycteris noctivagans*)		None	None	Yes	Found hibernating in hollow trees, under sloughing bark, in rock crevices, and occasionally under wood piles, in leaf litter, under foundations, and in buildings, mines and caves. Forages above the canopy, over open meadows, and in the riparian zone along water courses.
Western red bat LABL (*Lasiurus blossevillii*)		SSC[1]	None	Yes	Tree roosting bat that often roosts singularly, but nursery colonies are found with many females and their young. Associated with intact riparian habitat

Species	Image	State Status	Federal Status	Migration	Habitat
Fringed myotis MYTH (*Myotis thysanodes*)		None	None	Local movements to suitable hibernacula	Roosts in caves, mines, buildings, and crevices.
Pallid bat ANPA (*Antrozous pallidus*)		SSC[1]	None	Yes, but short distance	Inhabits low-elevation rocky and arid deserts and canyonlands, shrub-steppe grasslands, karst formations and higher elevation coniferous forests. Roosts include rocky outcrops and cliffs, caves, mines, trees (bole cavities of oaks and exfoliating ponderosa pine). Roost switching may occur daily or nightly.
Little brown myotis MYLU (*Myotis lucifugus*)		None	None	Yes	An ecological generalist, this species uses a wide variety of natural and man-made roost sites. Typically associated with forested areas.
California myotis MYCA (*Myotis californicus*)		None	None	Local movements to suitable hibernacula	Roosts alone or in small groups in caves, mines, rocky hillsides, under tree bark and in buildings

[1]SSC = California Species of Special Concern

References

California Department of Fish and Wildlife. 2016. CWHR life history accounts and range maps. Department of Fish and Wildlife, Biogeographic Data Branch. Sacramento, California. Available online: http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx. Last accessed 6.16.16.

Rainey, W. E., E. D. Pierson. 2004. Site 300 bat survey. Prepared by Rainey and Pierson for Lawrence Livermore National Laboratory Site 300. 50 pp.

Wildlife Acoustics (WA). 2015a. Kaleidoscope Pro 3 Analysis Software webpage: http://www.wildlifeacoustics.com/products/kaleidoscope-software . Last accessed 9.19.15.

Wildlife Acoustics (WA). 2015b. Bat Species Identification from Zero Crossing and Full Spectrum Echolocation Calls using HMMs, Fisher Scores, Unsupervised Clustering and Balanced Winnow Pairwise Classifiers. 27 pp.